

[H.A.S.C. No. 114-79]

**NATIONAL ACADEMIES STUDY ON PEER
REVIEW AND DESIGN COMPETITION IN
THE NNSA NATIONAL SECURITY
LABORATORIES**

HEARING

BEFORE THE

SUBCOMMITTEE ON STRATEGIC FORCES

OF THE

COMMITTEE ON ARMED SERVICES
HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTEENTH CONGRESS

SECOND SESSION

HEARING HELD
JANUARY 12, 2016



U.S. GOVERNMENT PUBLISHING OFFICE

98-888

WASHINGTON : 2016

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URITY LABORATORIES**

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ARMED SERVICES,
SUBCOMMITTEE ON STRATEGIC FORCES,
Washington, DC, Tuesday, January 12, 2016.

The subcommittee met, pursuant to call, at 3:31 p.m., in room 2118, Rayburn House Office Building, Hon. Mike Rogers (chairman of the subcommittee) presiding.

**OPENING STATEMENT OF HON. MIKE ROGERS, A REPRESENT-
ATIVE FROM ALABAMA, CHAIRMAN, SUBCOMMITTEE ON
STRATEGIC FORCES**

Mr. ROGERS. Good afternoon, the subcommittee will come to order. I want to welcome our witnesses, who are co-chairs of the National Academies of Science panel that conducted a study on these issues. Today's hearing is on Peer Review and Design Competition in the NNSA [National Nuclear Security Administration] National Security Laboratories.

This committee launched this study a few years ago because it wanted an objective, nonpartisan review of these two foundational aspects of our nuclear deterrent. Quoting from the committee report in 2013, quote: "The committee believes that peer review and design competitions are critical components of nuclear stockpile stewardship. Because of their importance, the committee believes that an independent assessment is needed to understand the effectiveness of current practices," closed quote.

It is clear that without effective peer review and design competition within our nuclear weapons labs, the long-term health and viability of our deterrent is in danger. So we asked the National Academies to review these two issues and give us their assessment. And at the risk of stealing their thunder, our witnesses are reporting that while, quote, "The state of peer review at the weapons labs is healthy and robust, the state of design competition is not. The NNSA complex must engage in robust design competitions in order to exercise the design and production skills that underpin stockpile stewardship and are necessary to meet evolving threats," close quote.

So the report card is mixed, and we need to understand why. More importantly, we need to hear the witnesses' recommendations on what we and the administration should be doing about it. Because at its core, the credibility of our nuclear deterrent rests on the ability of our scientists and engineers to design, build, and field weapons in a timely way. The witnesses state that the nuclear en-

terprise needs to exercise, on a regular ongoing basis, the full suite of nuclear weapons design, development, engineering, and production capabilities needed to respond to the evolving threats.

This committee has recently taken steps in this direction by creating the Stockpile Responsiveness Program, and the Foreign Nuclear Weapons Prototyping Program. I will be curious to hear what the witnesses think of these efforts and what more should be done.

Coupled with our Project Atom hearing in November, today's hearing should focus our efforts on preparing for the dynamic and highly uncertain nuclear future. We must ensure our nuclear enterprise is ready to meet the future. With the guidance of our witnesses, I am confident we can do just that. Thank you for testifying today and leading the study. We know it takes time to do these things, and we very much appreciate this time and effort.

Our witnesses today are Paul Peercy, co-chair, National Academies Study Committee that conducted this study and Dean Emeritus of the College of Engineering at the University of Wisconsin, Madison; and Dr. Jill Dahlburg, co-chair of the National Academies Study Committee. In her day job, Dr. Dahlburg is with the Naval Research Lab, although she is not here in that capacity today.

With that, let me turn to the ranking member, my friend and colleague from Tennessee, for any statement he would like to make.

[The prepared statement of Mr. Rogers can be found in the Appendix on page 19.]

STATEMENT OF HON. JIM COOPER, A REPRESENTATIVE FROM TENNESSEE, RANKING MEMBER, SUBCOMMITTEE ON STRATEGIC FORCES

Mr. COOPER. Thank you, Mr. Chairman. First of all, congratulations on the victory last night. I stayed up until midnight to see that. It was an amazing, amazing game. Second, I would like to ask unanimous consent to insert my opening statement for the record, as well as the testimony of Dr. Garwin and Dr. Schwitters. Unfortunately, they were not able to be here today, but—

Mr. ROGERS. Without objection.

[The information referred to can be found in the Appendix beginning on page 37.]

Mr. COOPER. Thank you. Thank you, Mr. Chairman. I look forward to the testimony of the witnesses. These are extremely important questions, and I hope that we can receive the wisdom of the panelists today and do the right thing for the country. Thank you, Mr. Chairman.

[The prepared statement of Mr. Cooper can be found in the Appendix on page 21.]

Mr. ROGERS. I thank the gentleman and the witnesses' joint statement will be entered, without objection, into the record.

Mr. ROGERS. I would also like to enter into the record the full report of the National Academy Study Committee. Without objection, that will be submitted as well.[†]

[The information referred to can be found in the Appendix on page 45.]

[†] The Summary from the report is included in the Appendix. The full report can be found at <http://www.nap.edu/read/21806/chapter/1>.

Mr. ROGERS. We have copies of the report for each of the members and have a few available for others as well.

We will now ask our witnesses to make 5-minute opening statements summarizing their statement. Dr. Peercy, we will start with you. You are recognized for 5 minutes.

STATEMENT OF DR. PAUL S. PEERCY, CO-CHAIR, COMMITTEE ON PEER REVIEW AND DESIGN COMPETITION RELATED TO NUCLEAR WEAPONS, NATIONAL ACADEMIES OF SCIENCES

Dr. PEERCY. Well, thank you, Mr. Chairman. And Mr. Chairman, Ranking Member Cooper, and members of the subcommittee, thank you for the opportunity to discuss the results of our National Academies report, Peer Review and Design Competition in the NNSA National Security Laboratories. My co-chair, Dr. Jill Dahlburg, and I have prepared this joint statement, and I want to ask Jill to please chime in at any time during my comments.

Our report was released on October 15, and it is a product of a very strong committee whose members have extensive experience and excellent credentials in this area. The statement of the task given to the National Academies for the study was specified as noted in the fiscal year 2013 National Defense Authorization Act [NDAA]. It charged our committee with assessing the quality and effectiveness of design competition. The charge specified particular dimensions of these assessments, which were carefully addressed in our study and report. The study was supported by the National Nuclear Security Administration which went out of its way to provide the committee with full information relevant to these tasks.

Let me begin with the bottom line, which Chairman Rogers has already noted. The state of peer review at the DOE [Department of Energy] weapons lab is healthy and robust, but the state of design competition is not.

The NNSA complex must engage in robust design competition to exercise design and production skills that underpin the stockpile stewardship, and are necessary to meet evolving threats.

Recent competitive design studies, such as the reliable replacement warhead, RRW, were useful design and modeling exercises, but were not true design competitions because they did not result in the creation of an engineering prototype, and the latter step is necessary to provide essential feedback on the viability and practicality of a design.

Therefore, the committee recommended that to exercise a full set of design skills necessary for an effective nuclear deterrent, the NNSA should develop and conduct the first of what the committee envisions as a series of design competitions that integrate the full, end-to-end process from novel design conception, through engineering, building, and non-nuclear testing of a prototype.

The process should exercise a full range of skills in the complex needed to produce a new weapon, but this should be done with the clear understanding that this prototype would be a nuclear device, not a warhead, and that the prototype would not enter the stockpile.

Maintaining nuclear weapon design skills through design competitions is necessary for our nuclear deterrent workforce to be fully capable of designing and building weapons to meet evolving

threats, understanding the status and direction of foreign nuclear weapons programs, and determining the best and most cost-effective approaches to resolving problems that arise during stockpile weapon surveillance and life extension programs.

It is important to emphasize that the scientists and engineers who designed and built the weapons currently in the stockpile have either retired, or soon will retire and these design-and-build competitions are essential for training the next generations of weapons designers for transferring the knowledge from the current generations to future generations, and for maintaining production skills within the NNSA complex.

The committee made other recommendations. I would like to bring three of these to your attention. The first, design competition between independent teams that use different approaches and methods are extremely valuable, especially in a system as complex as a nuclear weapon where we do not have comprehensive understanding of the physics. We also gain increased confidence in the safety and reliability of weapons in the stockpiles when they are assessed by independent teams using different approaches and methods.

These observations led the committee to recommend that Los Alamos and Lawrence Livermore National Laboratories continue to maintain independent design capabilities using different approaches and methods to enable independent peer review of critical technical issues. Sandia National Lab should, likewise, carry out, for high priority issues, competitive designs with independent teams that use different approaches followed by peer review of component subsystems and the full system.

Next, while noting that the peer review process is basically healthy, the committee recommended two minor changes to strengthen the peer review process.

And finally, the committee recommended steps to be followed in future design competitions to avoid the detrimental aspects of the RRW competition.

So, thank you again for the opportunity to testify today. And we remain at your disposal for questions.

[The joint prepared statement of Dr. Percy and Dr. Dahlburg can be found in the Appendix on page 22.]

Mr. ROGERS. And I thank you. Dr. Dahlburg, did you want to summarize your opening statement?

Dr. DAHLBURG. I would like to. Thank you very much.

Mr. ROGERS. You have an extra 5 minutes.

STATEMENT OF DR. JILL P. DAHLBURG, CO-CHAIR, COMMITTEE ON PEER REVIEW AND DESIGN COMPETITION RELATED TO NUCLEAR WEAPONS, NATIONAL ACADEMIES OF SCIENCES

Dr. DAHLBURG. Okay. So I would like to hark back to what Paul said, which is, it is important to emphasize the scientists and engineers who designed and built the weapons currently in the stockpile have either retired or soon will retire. And what we need to do is make sure that we have a cadre of people who are going to be able to maintain the stockpile into the indefinite future. I think

we all agree, as long as we have nuclear weapons, we must be confident in these weapons.

The analogy I often think of is, like, actually cooking. If you want to make something in the kitchen and you are trying to train someone else to make what you are already cooking, you can write down a recipe and they can follow it. If they have never cooked before, the odds are that they are not really going to know how to do it. You can make a video, and they can look at it and then try it from that. But the odds are, they are not going to have quite the same expertise as if they actually come in the kitchen with you, and they learn how to do what you mean by a pinch of salt, or by stirring the flour with the butter. And when you train that way, then you have a group of people who are going to be able to do what is necessary at each stage of replacement warheads, at each stage of designs in the future.

And I want to emphasize that what we are talking about are prototype devices. The design and fabrication should exercise the full range of skills needed to produce a new weapon. Doesn't mean produce one, it just means you have to make sure that these people know every aspect of what they are doing. The design should be able to be certified in a manner consistent with the testing moratorium. This is absolutely mandatory. The prototype nuclear explosive package should be fully integrated with all of the Sandia components. So it is not just the piece that the Livermore and Los Alamos might work on, but across all of the three laboratories.

If they require new Sandia electronic components, the prototypes of these components should also be designed and produced in parallel. And it should be a device, not a warhead. That is, stockpile-to-target type scenarios should be considered by assimilation or testing, but there should be no expectation of actually getting something that looks like it is going into the stockpile.

And this is, I believe, necessary in order to train that next generation workforce, which is every bit as important for a deterrent as the hardware that they are maintaining. That is my statement.

[The joint prepared statement of Dr. Dahlburg and Dr. Peercy can be found in the Appendix on page 22.]

Mr. ROGERS. Great, I appreciate the opening statements. We will now open to questions, and I recognize myself for the first set of questions. Dr. Peercy and Dr. Dahlburg, let's start with the good news you bring to us. Your team found that the peer review was strong, healthy within the NNSA labs. So tell us why.

Dr. PEERCY. I think it is there because it was built in from the early culture of excellence and a fear of failing, because they did not understand the materials they were using. So they really wanted, they wanted their designs peer reviewed by others before they put them into test.

Mr. ROGERS. How was that carried out, that peer review?

Dr. PEERCY. So that peer review started out being carried out, primarily, from other scientists in the same laboratory. And then as time passed and especially after Lawrence Livermore National Laboratories failed on its first three tests, the peer review became laboratory-to-laboratory much more. And in the case of Sandia National Laboratories, a branch was built in Lawrence Livermore,

and they reviewed the Albuquerque designs, and the Albuquerque team reviewed the Lawrence Livermore designs.

The cultures of those two branches were very different. The culture of the Sandia Lab in Livermore took on the culture of Lawrence Livermore National Lab and the culture of the Sandia Lab in Albuquerque took on the culture of the Los Alamos National Labs. And so that gave purely independent teams designing each other's work, and that is why we recommended that that be maintained going forward, especially for high-consequence items.

And we also recommended that the peer review be codified a bit more. Sandia has written guidelines for what type of peer review when, and we recommended that Los Alamos and Lawrence Livermore create their own short, written guidelines.

Dr. DAHLBURG. Yes, and actually short is to the point. We don't want this to turn into another process that becomes a time sink. Just something that they can explain. Because right now, they do very informal peer review, peer-to-peer, and it goes higher and higher until, finally, the lab director is involved, and there should be something of a checklist that says at the level of uncertainty, this is the kind of peer review that we require.

Mr. ROGERS. Good. How do the labs determine what level or types of peer review is required for various programs or projects and is the process formal, informal, ad hoc, or structured?

Dr. PEERCY. So the process has been a bit ad hoc at the nuclear design laboratories, Los Alamos and Livermore. Sandia is a much more formal process. And they continue to formalize it. And Sandia also has—although it does not have a complete—a competitor that does a complete end-to-end design of the non-nuclear components for a given weapon, if you look across American industry, every one of those different parts are designed and sold. So those are customers for Sandia, and they are also reviewers of Sandia.

Mr. ROGERS. Okay. Is the peer review process strong on the non-nuclear side of the business given that there is only one lab, Sandia, that is doing non-nuclear?

Dr. PEERCY. Yeah, it is strong, and it was made strong partly because the other—some other institutions, like the Department of Defense, use the same products, some of the same products; but, also, there are competitors in the private sector. And they provide the same products, and so there is competition, not on the complete spectrum from one company, but if you take—if you integrate all of the companies, you have the complete spectrum.

Mr. ROGERS. Okay. Let's move over to the less than good news side of the news you brought us. The report says your team, quote, "is deeply concerned about the state of the design competition in all three laboratories," closed quote. It goes on to say that, quote, "Recent design studies have been good analysis and modeling exercises, but they did not result in the actual engineering and fabrication of components and systems," closed quote.

Why is this distinction important, and why should the labs be pursuing actual engineering and prototype fabrication with a clear guidance that the weapon would not actually be produced and deployed?

Dr. PEERCY. I think the committee thinks that is important because we do not have complete understanding of the physics of the

materials and the processes that go into the weapon. So you look at—you do the best you can with experiments, but you can't reach all of the experimental region you need, and then you do models and simulation based on that. But you find that the two different labs' models give different answers. So the question is, which one is right?

Mr. ROGERS. Okay.

Dr. PEERCY. And that is why you do this.

Dr. DAHLBURG. And there are, in addition to the workforce, we need to understand the status and direction of foreign nuclear weapon programs, and we also need to determine the best and most cost-effective approaches to resolving problems that do arise during surveillance and the life extension programs. So these three are the key reasons.

Mr. ROGERS. Okay. The report notes that designing and producing prototypes of new nuclear weapons designs will help address evolving threats. Why does conducting modeling or computer simulations not get the job done here, and why do we need to go all the way to full designs and the building of prototypes? Your microphone.

Dr. PEERCY. Sorry. It was very clear for the nuclear components why you need to do the prototyping and testing. And——

Mr. ROGERS. Go ahead and explain why.

Dr. PEERCY. Pardon?

Mr. ROGERS. Go ahead and explain. You said it is obvious.

Dr. PEERCY. Oh, okay, because you don't know if the design is going to work. Right off the bat, you don't know first, if it is a viable design that can be built. A lot of the early designs could not be built.

Dr. DAHLBURG. And there is more than that. When you are doing a simulation, you are modeling the real world, and there are aspects in that simulation that you made assumptions, in many ways. The numerics themselves are assumptions, and the physics packages are also assumptions. So as you go into more and more extreme states of matter, in large cases, you are guessing because you can't have measured every point that you are simulating. Therefore, you have to do some form of validation with physics. And that is why you need to do actual experimentation.

Mr. ROGERS. Okay. Last thing I want to ask is, why does the report stress that a, quote, "clean slate," closed quote, design competition—why is that important?

Dr. PEERCY. So the committee thinks that is important because you want to stimulate the nuclear engineering package designers to think about how to design a new weapon, and you want to stimulate the Sandia National Labs, who have a lot of work doing life extension programs to actually think about how they would build the supporting electronics and systems for a different nuclear package.

So right now, the life extension programs only look at existing nuclear packages. And that exercises part of Sandia's expertise, but not all that is needed, and, of course, no new nuclear packages are being designed. So Los Alamos and Lawrence Livermore need that exercise.

Mr. ROGERS. If that clean-slate competition were pursued, does the administration 3+2 nuclear stockpile strategy exercise the full range of skills and design competition your study recommends?

Dr. PEERCY. We didn't hear much about the 3+2, but from what we heard about the 3+2, it does not exercise the full range. Because the 3+2 basically takes existing nuclear packages, or, at least, the footprint of those, and works around those.

Mr. ROGERS. Okay. With that, I yield to the ranking member for any questions he may have.

Mr. COOPER. Thank you, Mr. Chairman. I would like to explore first the degree of unanimity behind the report; first, of your committee members.

Dr. PEERCY. So all of the committee members agree with that report.

Mr. COOPER. So no dissenting views? No—

Dr. PEERCY. There was no minority views.

Mr. COOPER. How about among the reviewers?

Dr. PEERCY. Pardon?

Mr. COOPER. How about among the reviewers?

Dr. PEERCY. Well, the reviewers had a lot of suggested improvements, which we appreciate. But the reviewers, some of the reviewers did not fully support the conclusions of the report. I think that's a fair statement.

Dr. DAHLBURG. Yes. But in the end, I think we accommodated all of the reviewer comments in the document that you are holding.

Mr. COOPER. Are we allowed to see the reviewer comments?

Mr. WEIDMAN. No, they are held quiet within the Academy, by the Academy's guidelines.

Mr. COOPER. So is it fair to say that this is supported by the National Academies of Science, Engineering, and Medicine?

Dr. DAHLBURG. Yes. Absolutely.

Mr. COOPER. So how would you characterize the opinions of scientists who disagree with you, who are members of the Academy?

Dr. PEERCY. I don't know. I am—I suspect there are disagreeing opinions. In fact, I know there are two that I just saw this morning that I think you entered into the record. And I think there is a difference of opinion as to whether or not we actually have enough knowledge to design a new weapon if an adversary designs a new weapon and we need to move into a new space that we have not been in without a skilled workforce. And I think there is a big difference of opinion over that. You want to add to that?

Dr. DAHLBURG. Yeah, so that is why I started with my analogy about cooking. It is something that we all know. And my reason for being on this committee was that I truly feel that that workforce is an essential pillar of our nuclear deterrent.

So from the perspective of what we wrote, we wrote this in order to make sure that that workforce was going to continue into the next 30 to 50 years.

Mr. COOPER. I think you are touching on the core issue here, which is really a personnel issue.

Dr. DAHLBURG. Uh-huh.

Mr. COOPER. Especially the sensitive subject of quality of personnel. Some people who are brilliant refuse to work on nuclear weapons at all, in any form.

Dr. PEERCY. That is right.

Mr. COOPER. So we don't have that talent pool. So we have to make do with those who are willing to do this work, this necessary work. So how do we cope with this? You use a cooking analogy. That is important, and I don't want to cut you off, Dr. Peercy. Go ahead if you would like.

Dr. PEERCY. I was just going to say that the NNSA is responsible for providing and maintaining the capabilities necessary to sustain a safe, secure, and reliable nuclear weapons stockpile for the Nation and its allies. And using her analogy and other analogies, if you don't know how to build a weapon because you've never built one, and there is—and you can't even write down the recipes for it on paper, how do you know you have got—you have maintained the capabilities to sustain that nuclear weapon stockpile for the Nation and its allies?

Mr. COOPER. Well, let's be very careful how we speak here, because to say there are no recipes, I think would be inaccurate. Dr. Dahlburg was saying, you know, there is knowledge retention. It is a question of actually doing it, the cooking process, the pinch of salt, the stirring in the butter, whatever the analogy is. In medicine, in residency training, each one, treat one, teach one. But here, you are cutting it more finely, because you are talking about a prototype, a nuclear device; not a warhead. But what works is a warhead. So you are stopping short. You want a real-world competition, but then you don't want to actually build anything.

So this is a very tricky dividing line here. How do you make it real without it being real? And one element that was completely missing from the report is the State Department aspect, because you are kind of assuming that other nations won't see this as a threat or a problem when there is no input from that sphere. A further question is, we do a lot of forensic work on other things, and we learn a lot from that. And that is not as a competition right there using—that is more of an Olympics than what you are talking about. You are talking about a national competition, not an international Olympic competition. So there are a lot of moving pieces here, but, fundamentally, these are personnel issues. And personnel issues are very difficult to address.

Dr. DAHLBURG. And so, I guess we are both scientists, and applied physicists, and so speaking from our personal experience, if you don't actually compare your work with experimentation, you can delude yourself very easily. Now, I recognize NNSA has done a marvelous job categorizing the large body of knowledge that exists. This is, indeed, the case. It is the workforce, and it is our opinion that if we want to maintain that for 30 years, we better have a little bit more hands-on experience. And so—

Mr. COOPER. But you limit the degree of hands-on experience.

Dr. DAHLBURG. Well, for two reasons. One is that we are responding to an NNSA charge. So we spoke within the sphere of the NNSA. So our goal was to make sure that the NNSA complex is entirely addressed. Beyond that, the report did not—

Mr. COOPER. But the goal is a safe, secure, and reliable stockpile. It is not pleasing NNSA bureaucrats.

Dr. DAHLBURG. Oh, heavens no. But it is—oh, no, no, no, no, no, that is not what I meant. What I meant is, we were addressing a

charge. In a report of this nature, the recommendations can only recommend back to NNSA. So we can't go outside of that and recommend to the State Department or to other agencies.

Mr. COOPER. Would the recommendations have been different if you had been able to recommend to other agencies, if the leash had been—

Dr. PEERCY. We probably would have taken this further. There was discussion among the committee about flight tests. And we did not recommend flight tests for three reasons. One reason was we wanted to keep it within the current budget. We didn't want to see a big—a large expense that has to be in place. Second reason is that we wanted to make sure we didn't send the wrong signal as to why we were doing this program, and flight—to an adversary, flight test might do that. But the third reason is, flight tests are in the purview of the Department of Defense [DOD], and not the Department of Energy. And we were charged within the NNSA purview.

Mr. COOPER. And you don't fear that subcritical testing would have any of those negative implications?

Dr. PEERCY. No, I don't fear the subcritical testing would have those, as long as there are no nuclear emissions.

Mr. COOPER. But you put your own blinders on not wanting to deal with State Department issues, or budget issues, or DOD issues, or—

Dr. DAHLBURG. Well, I think that is—we tried to stay true to the charge. And so the charge itself was to actually address the quality of the peer review, the incentives for peer review. We are done with those. The alternate methods for peer review, we addressed that, and then where design competition is, what is the health and status and what is going to happen to design competition. And so that was what the report was about. If you would like to charge us to do another report, the same committee would probably—

Dr. PEERCY. Then broaden it. We would be happy to do that.

Mr. COOPER. The challenge in life is to get at the truth. No one can ever achieve it completely. But we are trying to—

Dr. DAHLBURG. Of course.

Mr. COOPER [continuing]. Model it. And it is very difficult—

Dr. DAHLBURG. Of course.

Mr. COOPER [continuing]. Because there are a lot of moving parts here. But I have overstayed my welcome. I will let the chairman move on. I know Dr. Fleming is here.

Mr. ROGERS. The Chair now recognizes the gentleman from Louisiana, Dr. Fleming, for 5 minutes.

Dr. FLEMING. Thank you, and thank you to our panel team. Just so I can understand some of the statements that you make is kind of filled with jargon, and kind of vague references. So I want to try to understand. What we have is a stockpile of nuclear weapons, which, for the most part, were built many years ago. The people who built them, for the most part, probably have retired or died by now. And what I think you are saying is, beyond other things, you want to create a whole other generation of people who are capable of keeping up the stockpile, overhauling them when necessary, and maybe even some day replacing them, if necessary.

We are already talking about the modernization of weapons. I remember when I first came to Congress in 2009, getting a lecture on the fact that we were still using what was equivalent to television tube technology in some of our nuclear weapons. Obviously, something—I mean, you wouldn’t—probably wouldn’t find a television repairman today, much less one who could actually fix a TV like that.

So I get all of that. That makes a lot of sense. But when you said that you have to test it to validate it, and it makes a lot of sense, how far do you take that? Do you actually do some type of near-nuclear reaction, or simulated reaction, or how far do you get along the line to actually validate the accuracy of your studies?

Dr. PEERCY. So that is a very good question because you can do a lot of tests on the components and the subsystems, and then if you want to test the full system, you would take out the warhead. You take out the nuclear package, and put in a dummy package that behaves like the nuclear package but does not have any radioactive material.

Dr. FLEMING. Right.

Dr. PEERCY. Okay. So that will test the full system.

Dr. FLEMING. Right.

Dr. PEERCY. And you hopefully can test without any nuclear explosions, the nuclear package independently.

Dr. FLEMING. So you understand that nuclear trigger and, obviously, the response of plutonium, or whatever that you have in there. So you go all the way up to that point with the various interacting systems which you have to modernize going forward.

Dr. DAHLBURG. And also the complex itself. So I will use a completely different build, so that I don’t get in any trouble. Say you are building a space flight instrument. Okay? And so you have this instrument and you are going to have to get it to technology ready—TRL [technology readiness level] level 9, and it is going to go in a satellite. In order to do that, you have to design it; then you have to make sure that you can procure the parts. You have to work with someone who might build a camera; have to understand the electronics, and so on. And in order to do all of this, you have to reach into different places of the space flight hardware community.

Dr. FLEMING. Uh-huh.

Dr. DAHLBURG. Similarly, with the NNSA, there are many different places that someone who is designing this instrument is going to need to go. And if you don’t go as far as a design, you won’t be testing that aspect. Do I know the telephone numbers? Can I actually call somebody at the plant and see if they can build this thing? So it is that part of the testing that we are talking about.

Dr. FLEMING. Yeah, so it sounds like to me that you wouldn’t even be coming close to violating any sort of test bans or anything like that because you are not really using directly nuclear material. You are using all of the devices up to that point?

Dr. PEERCY. That is correct.

Dr. FLEMING. So that is important. So the National Nuclear Security Administration’s labs are not doing the weapons designs needed for the eventuality to modernize nuclear weapons arsenal.

So my question is this: The report states that your study group is deeply concerned about the state of design competition at all three laboratories. Would you please elaborate on this concern? What specifically concerns you about this? I know you have touched on it some, but maybe you can encapsulate that.

Dr. PEERCY. So, I think the concern about the design competition was that we have not really had a design competition for the full weapon since 1992. Right. There have been some modeling and simulations, but that doesn't tell you if they are going to work. And then when you look at the non-nuclear parts of the weapon, and Jill touched on this, look at how fast the electronics changes, how fast communication changes. I mean, you are not going to be able to buy the components in those weapons that are in there today. You are going to have to design whole new ones. You may not find an industry out there that is building those. Then you have got to build them in-house. And you have got to know what you need, and you have got to have the experts to do it.

Dr. FLEMING. Okay. And so the advantage of prototyping is you may know all of the systems work perfectly, but you don't know if they all work perfectly together. Would that be a fair—

Dr. PEERCY. That is correct.

Dr. FLEMING. Okay. Okay. Well, I think that answers my questions. Thank you.

Mr. ROGERS. I thank the gentleman. We have just been called for votes. But I wanted to just close with one question first, before I recognize the ranking member for any closing questions.

How did your recommendation for design competition align with the programs this committee has created through legislation in recent years? Specifically, with the Stockpile Responsiveness Program created by section 3112 of the fiscal year 2016 NDAA?

Dr. PEERCY. I think it is very well-aligned. I think the two are quite well-aligned. I think your legislation goes further. It goes with the flight tests, but other than that, they are the same.

Mr. ROGERS. Would you recommend any modifications to our legislation?

Dr. PEERCY. I don't have any. No, I think it is very good.

Mr. ROGERS. Great. All right. Does the ranking member have any more questions?

Mr. COOPER. Do the heads of Los Alamos or Sandia or Lawrence Livermore have the authority today, when they evaluate personnel, to test them and see how good they are at solving problems, including design problems?

Dr. PEERCY. I would assume so. Yeah.

Mr. COOPER. So are we really talking about anything new here, except an extramural way of formally having a process of competition, because in competition, some people win, some people lose.

Dr. PEERCY. I think the thing that we are talking about is, when you do a design and you don't understand the physics, you don't know if what you have designed will work. And that's the bottom line.

Mr. COOPER. But we have competency testing for physicists, and some are better than others.

Dr. PEERCY. That is certainly true.

Mr. COOPER. And, presumably, lab directors pay and reward those who do a better job.

Dr. DAHLBURG. Sure, but——

Mr. COOPER. And they test them with real-world circumstances. They are doing testing today. They are not sitting on their hands.

Dr. DAHLBURG. No, it is true. But that is why we have—I mean, as you know, we have experimental science because even the best physicists in the world can be surprised by——

Mr. COOPER. But they are testing today, different things.

Dr. PEERCY. They are testing the capability of given a problem in which you actually can figure out the physics, you can solve that problem. Now, if I give you a problem which you can't solve, you can't solve it. And that is what we are talking about.

Mr. COOPER. Well, you have confused me, but not being a physicist, I am somewhat handicapped, but I will turn that over to the chairman.

Mr. ROGERS. Someone who is really handicapped there. Listen, thank you all very much. You have been very helpful. We appreciate your participation. For other members who couldn't be here to ask some questions, we will submit to you in writing, and then ask that you respond to those in a timely manner if you could. With that, this hearing is adjourned.

[Whereupon, at 4:10 p.m., the subcommittee was adjourned.]

A P P E N D I X

JANUARY 12, 2016

PREPARED STATEMENTS SUBMITTED FOR THE RECORD

JANUARY 12, 2016

Opening Remarks – As Prepared for Delivery

**The Honorable Mike Rogers
Chairman, Subcommittee on Strategic Forces
House Armed Services Committee**

**Hearing on “National Academies Study on Peer Review and Design Competition in the
NNSA National Security Laboratories”**

January 12, 2016

Good afternoon. The subcommittee will come to order.

Welcome to our hearing on *Peer Review and Design Competition in the NNSA National Security Laboratories*.

I welcome our witnesses, who are the co-chairs of a National Academies of Science panel that conducted a study of these issues.

This committee launched this study a few years ago because it wanted an objective, non-partisan review of these two foundational aspects of our nuclear deterrent. Quoting from the committee report in 2013:

“The committee believes that peer review and design competition are critical components of nuclear stockpile stewardship...Because of [their] importance, the committee believes an independent assessment is needed to understand the effectiveness of current practices.”

It is clear that without effective peer review and design competition within our nuclear weapons labs, the long-term health and viability of our deterrent is in danger.

So we asked the National Academies to review these two issues and give us their assessment. And at the risk of stealing their thunder, our witnesses are reporting that while:

“the state of peer review at the weapons labs is healthy and robust, the state of design competition is not. The NNSA complex must engage in robust design competitions in order to exercise the design and production skills that underpin stockpile stewardship and are necessary to meet evolving threats.”

So the report card is mixed, and we need to understand why. More importantly, we need to hear the witnesses’ recommendations on what we and the Administration should be doing about it.

Because at its core, the credibility of our nuclear deterrent rests on the ability of our scientists and engineers to design, build, and field weapons in a *timely* way.

The witnesses state that the nuclear enterprise needs to exercise—on a regular and ongoing basis—the full suite of nuclear weapons design, development, engineering, and production capabilities needed to respond to evolving threats.

This committee has recently taken some steps in this direction by creating the Stockpile Responsiveness Program and the Foreign Nuclear Weapon Prototyping Program. I'll be curious to hear what the witnesses think of these efforts and what more should be done.

Coupled with our *Project Atom* hearing in November, today's hearing should focus our efforts on preparing for the dynamic and highly uncertain nuclear future.

We must ensure our nuclear enterprise is ready to meet this future.

With the guidance of our witnesses I'm confident we can do just that. Thank you for testifying today and for leading this study. We know it takes time to do these things, and we appreciate it.

- **Dr. Paul Percy**
Co-Chair
Committee on Peer Review and Design Competition Related to Nuclear Weapons
National Academies of Sciences
- **Dr. Jill Dahlburg**
Co-Chair
Committee on Peer Review and Design Competition Related to Nuclear Weapons
National Academies of Sciences

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Opening Statement
Ranking Member Jim Cooper
Hearing on the National Academies Study on Peer Review and Design
Competition in the NNSA National Security Laboratories
January 12, 2016

I join Chairman Rogers in welcoming Dr. Peercy and Dr. Dahlburg as witnesses to this hearing on the NAS report on peer review and design competition for the national security laboratories. I would also like to submit for the record comments on the NAS report by Dr. Richard Garwin and Dr. Roy Schwitters, both members of the prominent JASON scientific group.

The unique capabilities at the laboratories underpin our strong deterrent. We must continue to attract and retain the best scientists to maintain a robust nuclear deterrent, and to work on the most pressing national security issues, including nuclear nonproliferation and counter-terrorism.

I look forward to the discussion on the recommendations of the report. I would, however, like to raise several questions about the fourth recommendation of the report urging the laboratories to build prototypes of new nuclear weapons. While the FY15 National Defense Authorization Act required a plan to design and manufacture prototypes of foreign nuclear weapons to better understand foreign capabilities, this recommendation urges developing new prototypes based on a clean slate to exercise design skills. There are several risks with this approach and questions about whether it is necessary.

Dr. Schwitters in his comments stated that this recommendation was “vague and poorly supported” and “there is “no basis for anticipating its value to the US deterrence, its chances of success, or its potential for launching unintended deleterious consequences.” Dr. Garwin commented that “the “great emphasis on ‘design competition’ in the nature of competitive designs of new warheads for missiles or bombs seriously misses the point and does not assess the very substantial costs – both opportunity costs and the spur that such a program gives to international competitors and potential enemies, who have much more to gain from innovations and weapon development that does the United States.”

Further debate informed by more in-depth analysis is warranted, particularly on the potential consequences of such an approach , as we balance how best to strengthen national security and retain critical skills for our defense.

Testimony of

Dr. Paul S. Peercy
Dean Emeritus
University of Wisconsin
and
Co-Chair

National Research Council Committee on Peer Review and Design Competition
Related to Nuclear Weapons

And

Dr. Jill P. Dahlburg
Superintendent, Space Science Division
Naval Research Laboratory
and
Co-Chair

National Research Council Committee on Peer Review and Design Competition
Related to Nuclear Weapons

Before the

Strategic Forces Subcommittee
House Armed Services Committee

January 12, 2016

**Peer Review and Design Competition in the NNSA National Security Laboratories
Congressional Hearing Testimony
January 12, 2016**

**Paul Percy, University of Wisconsin, study co-chair
Jill Dahlburg, Naval Research Laboratory, study co-chair**

Thank you for the opportunity to discuss the results of our National Academies report, *Peer Review and Design Competition in the NNSA National Security Laboratories*, which I had the privilege to co-chair. My co-chair, Dr. Jill Dahlburg, and I have prepared this joint statement.

At the end of this statement you will find a list of the committee members and their affiliations. Their bios are in an Appendix to our report, which itself has been entered into the hearing record. This was a very strong committee whose members have extensive experience and excellent credentials in this area.

The Statement of the Task given to the National Academies for this study was specified in the FY2013 National Defense Authorization Act and reads as follows:

The study will assess the following:

- The quality and effectiveness of peer review of designs, development plans, engineering and scientific activities, and priorities related to both nuclear and non-nuclear aspects of nuclear weapons;
- Incentives for effective peer review;
- The potential effectiveness, efficiency, and cost of alternative methods of conducting peer review and design competition related to both nuclear and non-nuclear aspects of nuclear weapons, as compared to current methods;
- Known instances where current peer review practices and design competition succeeded or failed in finding problems or potential problems; and
- How peer review practices related to both nuclear and non-nuclear aspects of nuclear weapons should be adjusted as the three National Nuclear Security Administration (NNSA) laboratories transition to a broader national security mission.

The study was supported by the National Nuclear Security Administration, which went out of its way to provide the committee with full information relevant to these Tasks.

Let's begin with the bottom line: The state of Peer Review at the DOE Weapons Labs is healthy and robust, but the state of Design Competition is not. The NNSA complex must engage in

robust design competitions in order to exercise the design and production skills that underpin stockpile stewardship and are necessary to meet evolving threats.

Recent competitive design studies such as the Reliable Replacement Warhead (RRW) were useful design and modeling exercises, but were not true design studies, because they did not result in the production of an engineering prototype—a step necessary for essential feedback on the viability and practicality of a design.

This observation led the committee to develop the following recommendation:

To exercise the full set of design skills necessary for an effective nuclear deterrent, the NNSA should develop and conduct the first in what the committee envisions to be a series of design competitions that integrate the full end-to-end process from novel design conception through engineering, building, and non-nuclear testing of a prototype. These competitions should be implemented with the clear understanding that the resulting prototype would not enter the stockpile.

To elucidate what the Committee means by a prototype nuclear device, the prototypes produced by the design competitions should have the following characteristics:

- The design and fabrication of the prototype should exercise the full range of skills the nuclear weapons complex needs to produce a new weapon;
- The design should be able to be certified in a manner consistent with the nuclear testing moratorium;
- The prototype Nuclear Explosive Package (NEP) should be fully integrated with all Sandia National Laboratories components needed for a warhead. If the NEP design requires new Sandia components, prototypes of those components should be designed and produced in parallel; and,
- It should be a “nuclear device,” not a warhead. That is, stockpile-to-target-type scenarios should be considered via simulation or testing, but there should be no expectation of flight testing.

Maintaining nuclear weapon design skills through design competitions at the NNSA laboratories—as well as production skills within the NNSA complex—is essential if the nation is to achieve three critical objectives:

- Maintain a credible nuclear deterrent workforce that is fully capable of designing and building weapons to meet evolving threats;
- Understand the status and direction of foreign nuclear weapon programs, thus strengthening the nonproliferation regime;
- Determine the best and most cost-effective approaches to resolving problems that arise during stockpile weapon surveillance and life extension programs.

We wish to emphasize that all of the scientists and engineers who designed and built the weapons currently in the stockpile have retired or soon will retire, and these design-and-build competitions are essential to train the next generation of weapons designers and transfer the knowledge from the current generation to future generations.

The Committee made other recommendations. I would like to bring three of these to your attention.

First, the community has learned from experience that design competition between independent teams that use different approaches and methods is extremely valuable, especially in a system as complex as a nuclear weapon where we do not have sufficient knowledge to solve the problem from first principles.

Innovations produced by design competitions during the Cold War, as well as increased confidence in the safety and reliability of stockpile weapons that result from current assessment processes, such as the Independent Nuclear Weapons Assessment Process (INWAP), illustrate the value of having independent teams, using different approaches and methods, tackle common problems.

These observations led the committee to recommend the following:

Los Alamos and Lawrence Livermore National Labs should continue to maintain independent design capabilities, using different approaches and methods, to enable independent peer review of critical technical issues. Sandia National Labs should likewise carry out, for high-priority issues, competitive designs with independent teams that use different approaches followed by peer reviews of components, sub-systems, and full systems.

Next, while the Committee found that Peer Review processes at the NNSA Labs are basically healthy, the Committee felt they could be improved with two minor changes:

- Los Alamos and Lawrence Livermore should ensure they have a short, written guidance for a graded approach to peer review with the rigor appropriate to the stage of work and range of technical activities being reviewed.
- Sandia Labs should strengthen and broaden the use of outside experts on its peer review teams, as articulated in written guidance that SNL recently finalized.

Finally, the Committee heard a lot about the Reusable, Reliable Warhead competition. We hesitate to call it a design competition, because it was not. In addition, its execution was flawed. Although it succeeded in producing innovative weapon designs by the competing teams, its value was reduced because technical experts from the competing laboratories were not given the opportunity to critique one another's ideas through inter-laboratory peer review and to address criticisms at the science and engineering level before the final designs were formally presented to NNSA and potential end users. This precluded the full benefits of

technical competition and was a set-back to inter-laboratory cooperation. Therefore, the committee makes the following recommendation:

To guide future design studies and design competitions, the NNSA should provide a formal written statement articulating the design requirements and objectives, along with the selection criteria, in advance of any authorized work. The NNSA should also ensure that inter-laboratory peer review takes place, and that competitors have an opportunity to address criticisms at the science and engineering level before the results are formally presented to stakeholders outside of the NNSA.

Members of the Study Committee

PAUL S. PEERCY¹, University of Wisconsin-Madison, co-chair
 JILL P. DAHLBURG, Naval Research Laboratory, co-chair
 JOHN F. AHEARNE¹, Sigma Xi, The Scientific Research Society
 MICHAEL R. ANASTASIO, Los Alamos National Laboratory (retired)
 CHRISTINA A. BACK, General Atomics
 JOHN M. CORNWALL, University of California, Los Angeles
 PAUL A. FLEURY^{1,2}, Yale University
 DAVID HAMMER, Cornell University
 CHERRY A. MURRAY^{1,2}, Harvard University
 ROBERT E. NICKELL¹, Applied Science & Technology^{*}
 DAVID OVERSKEI, Decision Factors, Inc.
 K. LEE PEDDICORD, Texas A&M University
 ROBERT SELDEN, Independent Consultant
 STEVEN J. ZINKLE¹, University of Tennessee, Knoxville

¹ Member, National Academy of Engineering

² Member, National Academy of Sciences

^{*} deceased

PAUL S. PEERCY (*Co-Chair*) is a professor emeritus at the University of Wisconsin, Madison, where until 2013 he had served as dean of the College of Engineering. He came to the university in September 1999 from SEMI/SEMATECH, where he had been president since 1995. Before that, he was director of the Microelectronics and Photonics R&D Core Competency at Sandia National Laboratories. His research interests include phase transitions in solids, ferroelectricity, Raman and Brillouin scattering studies of solids, ion–solid interactions, laser-induced phase transformations, microelectronics and photonics, and solid state devices. He is the author or coauthor of more than 185 technical papers and holds two patents. Dr. Percy is a distinguished member of the Tau Beta Pi Engineering Honor Society; a fellow of the American Association for the Advancement of Science (AAAS), the American Physical Society (APS), and the Institute of Electrical and Electronics Engineers (IEEE); and a member of the National Academy of Engineering (NAE). He received his Ph.D. in physics from the University of Wisconsin, Madison, in 1966. He was a member of the 2012-2013 NRC Committee to Review the Quality of the Management and of the Science and Engineering Research at the Department of Energy National Security Laboratories—Phase II.

JILL P. DAHLBURG (*Co-Chair*) is superintendent of the Space Science Division at the Naval Research Laboratory (NRL) and a member of the Senior Executive Service since December 2007. Dr. Dahlburg served as NRL senior scientist for science applications from June 2003 to December 2007. From 2001 to mid-2003, she left NRL to work for General Atomics as the director of the Division of Inertial Fusion Technology and codirector of the Theory and Computing Center. In 2000, she served as head of the NRL Tactical Electronic Warfare Division Distributed Sensor Technology Office, where she was co-principal investigator for the first year of development of the small, expendable unmanned aerial vehicle Dragon Eye, which saw active duty in Iraq. Dr. Dahlburg holds a B.A. (1978) from St. John's College in Annapolis and an M.S. in physics (1980) and a Ph.D. in theoretical physics (1985) from the College of William and Mary. A fellow of the APS, she has served as chair of the APS Division of Plasma Physics, chair of the APS Topical Group on Energy Research and Applications, chair of the APS Panel on Public Affairs, and chair of the APS Mid-Atlantic Section. She also served as a member of the Lawrence Livermore National Laboratory (LLNL) Defense and Nuclear Technologies Director's Review Committee (2001-2007), chair of the Department of Energy (DOE) Advanced Scientific Computing Advisory Committee (2005-2007), and chair of the Department of the Navy's Space Experiments Review Board (2006-present). She was a member of the 2012-2013 NRC Committee to Review the Quality of the Management and of the Science and Engineering Research at the Department of Energy National Security Laboratories—Phase II.

**DISCLOSURE FORM FOR WITNESSES
COMMITTEE ON ARMED SERVICES
U.S. HOUSE OF REPRESENTATIVES**

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Witness name: Paul S. Peercy

Capacity in which appearing: (check one)

☐ Individual

☐ Representative

If appearing in a representative capacity, name of the company, association or other entity being represented: National Academies of Sciences, Engineering, and Medicine

Federal Contract or Grant Information: If you or the entity you represent before the Committee on Armed Services has contracts (including subcontracts) or grants (including subgrants) with the federal government, please provide the following information:

2015

Federal grant/ contract	Federal agency	Dollar value	Subject of contract or grant
DE-PI0000010/DE-DT0009721	NNSA	\$362,000	US-China Workshops
DE-PI0000010/DE-DT0009722	NNSA	\$419,101	U.S.- India Nuclear Dialogue

2014

Federal grant/ contract	Federal agency	Dollar value	Subject of contract or grant
DE-PI0000010/DE-DT0007382	NNSA	\$1,420,297	State of Molybdenum-99
DE-PI0000010/DE-DT0007972	NNSA	\$318,068	US-China Nuclear Materials
DE-PI0000010/DE-DT0007443	NNSA	\$1,127,327	Elimin. HEU in Res. Reactors

2013

Federal grant/ contract	Federal agency	Dollar value	Subject of contract or grant
DE-PI0000010/DE-DT0006061	NNSA	\$1,521,2221	Assessment of the Government Structure of the NNSA National Security Laboratory

Foreign Government Contract or Payment Information: If you or the entity you represent before the Committee on Armed Services has contracts or payments originating from a foreign government, please provide the following information:

2015

Foreign contract/ payment	Foreign government	Dollar value	Subject of contract or payment
none			

2014

Foreign contract/ payment	Foreign government	Dollar value	Subject of contract or payment
none			

2013

Foreign contract/ payment	Foreign government	Dollar value	Subject of contract or payment
none			

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Witness name: Jill P. Dahlburg

Capacity in which appearing: (check one)

☐ Individual

☒ Representative

If appearing in a representative capacity, name of the company, association or other entity being represented: National Academies of Sciences, Engineering, and Medicine

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DE-PI0000010/DE-DT0007443	NNSA	\$1,127,327	Elimin. HEU in Res. Reactors

2013

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2015

Foreign contract/ payment	Foreign government	Dollar value	Subject of contract or payment
none			

2014

Foreign contract/ payment	Foreign government	Dollar value	Subject of contract or payment
none			

2013

Foreign contract/ payment	Foreign government	Dollar value	Subject of contract or payment
none			

DOCUMENTS SUBMITTED FOR THE RECORD

JANUARY 12, 2016

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January 11, 2016

Chairman Mike Rogers
Ranking Member Jim Cooper
Strategic Forces Subcommittee
House Armed Services Committee
Rayburn 2216
House of Representatives
Washington, DC 20515

Dear Mike Rogers and Jim Cooper,

The NAS report on "Peer Review and Design Competition ..." provides useful commentary on peer review and background on the nuclear weapons design and maintenance process.

However, I believe that the great emphasis on "design competition" in the nature of competitive designs of new warheads for missiles or bombs seriously misses the point and does not assess the very substantial costs-- both opportunity costs and the spur that such a program gives to international competitors and potential enemies, who have much more to gain from innovations and weapon development than does the United States. The appearance of continuous active nuclear weapon design competition can have negative as well as positive benefit.

I particularly take exception to the argument that the U.S. nuclear deterrent is impaired by the lack of a visible series of competitive designs and prototyping of new nuclear warheads and bombs. I can understand that whatever the merit of an argument, it can apparently be strengthened by indicating that without the proposed program, U.S. deterrence of nuclear war or war in general will suffer,

"p. 5: they did not exercise the complete set of skills required in the NNSA complex to design nuclear weapons that would be an effective deterrent, nor was the credibility of any design assessed by fabricating a device or by non-nuclear testing."

but we have had experience with this argument before:

In support of the National Ignition Facility, in the years following the 1992 moratorium on nuclear testing initiated by the Administration of President George H.W. Bush, it was argued that without continued nuclear explosion testing, evident the world over by seismic records of the underground nuclear explosions at the U.S. national test site, nuclear deterrence could be maintained only by the achievement of "ignition" at NIF. I took the other side in this discussion, arguing that such a proposal was self-serving and

that the argument itself contributed to the *weakening* of deterrence, because the United States clearly had many nuclear weapons which had been tested and could be maintained indefinitely in the future by what is known now as a LEP (Life Extension Program); More particularly, the suggestion that such a force-in-being of tested nuclear weapons suffered in deterrent value because ignition could not be achieved in a charge of fusion fuel a million times smaller than that in a weapon was both logically deficient and both politically and technically wrong headed. Unforeseen difficulties, either in principle or in practice might prevent the achievement of ignition at NIF, without in any way impairing the continued ability of the United States to produce two-stage thermonuclear weapons.

And that is how it turned out—failure to achieve ignition, but few had believed the hype.

Thus I think it is highly undesirable to argue that routine design competitions, through the prototype stage of the nuclear explosive package-- NEP-- are essential to the maintenance of robust U.S. nuclear deterrence.

In fact, I have no animosity to the idea of design competition and proposed such in a paper of 2008 and in my testimony to the congressionally mandated Commission on the Strategic Posture of the United States.¹ As for motivation of the technical teams in the two NNSA design labs, I judge that effectively contributing to the continuing effectiveness of the stockpile through life extension programs (LEP) is judged a worthier goal than winning a football-game-like competition.

There are very substantial costs associated with such design competition, and goals of infrastructure advancement should be to reduce greatly the cost of activities in the U.S. nuclear weapon design laboratories, and also the time required for planning, programming, and carrying out such programs.

Furthermore, the Report states, *"Moreover, as other nations pursue new designs or strategies that could constitute serious threat evolutions, the United States could find itself in a precarious security situation were it not to maintain nuclear weapon design, development, and production skills to address such evolving demands."* implying that new U.S. nuclear weapons would be necessary to respond to new nuclear weapon designs by others. This is rarely the case.

The Report makes a stab at stating the magnitude of the effort required in such a design competition,

"Roughly speaking, the committee imagines a design competition as involving a few dozen laboratory staff members, with a larger number in the first year of each competition, plus some prototype development and experiments up to and including hydrodynamic tests. These parameters suggest a scale for the endeavor that the committee deems appropriate."

¹ <http://fas.org/rlg/9007TEST1.pdf>
https://www.armscontrol.org/act/2008_12/Garwin "A Different Kind of Complex: The Future of U.S. Nuclear Weapons and the Nuclear Weapons Enterprise," by R.L. Garwin includes
"Yet, the work done so far on the RRIW program has re-energized the nuclear laboratories and their involvement in the nuclear weapons complex. Such a major effort should be undertaken every five years or so. I know firsthand from my involvement with this program that new insights have arisen from the new focus on simulation and computation."

but the authors neither provide any rationale for this statement, nor work out its program cost or opportunity cost. And in my opinion it does not go far enough, because the NEP is not a weapon in itself, until it is integrated with the bomb or warhead, on which it puts demands, and which, in turn, influence the design of the NEP.

The load and vibration characteristics of Navy and Air Force-strategic reentry vehicles and their corresponding NEPs are quite different-- posing now well-recognized impediments to the "3 + 2" approach.

The Labs do important work in areas of nonproliferation and counter-terrorism, in a much larger volume of design space than would be involved in analyzing and developing alternative warheads for the U.S. stockpile. As with learning a foreign language, this provides insights into elements of U.S. weapons.

Since the Administration of President George H.W. Bush, the U.S. nuclear weapon program has been based on the judgment that the U.S. does not need new nuclear weapon capabilities-- a judgment that I share. The continued viability of the nuclear deterrent has been focused on ensuring that the U.S. nuclear weapons will continue to function decade after decade, by LEPs that include, if necessary, production of new plutonium pits, refreshment of the high explosive and other elements subject to deterioration, and the substitution of thoroughly tested components either in the NEP or external to it.

It should be repeated that many of the aspects of a nuclear explosion important in wartime have never been tested in underground nuclear explosion tests, where the NEP is at rest, surrounded by rock rather than by air, not subject to rotation or deceleration in the range of tens of times that of gravity, and the like. It is strange, therefore, that the essential role of realistic "flight testing" now achieved with the "HFJTA"—High-Fidelity Joint Test Assembly-- is eliminated from the requirement for prototypes.

Finally, if the United States argues that the continued development and readiness for manufacture of nuclear weapons with new characteristics is essential to its deterrence, how can other states resist such arguments from their nuclear weapon establishments? Is it really in the United States interest to have vigorous competitions not only between two U.S. nuclear weapon design laboratories but also among all the weapon labs of the world? And what impact will ongoing vigorous design competitions have on the resolve of non-nuclear-weapon state members of the NPT to support the NPT and the CTBT?

Far better is continued emphasis on improving the robustness of command and control, surety of nuclear weapons storage and transport, and increased capability for preventing nuclear weapon theft.

/ Richard L. Garwin /

Richard L. Garwin

Relevant biography at https://www.armscontrol.org/act/2008_12/Garwin and also appended.

Richard L. Garwin was born in Cleveland, Ohio, in 1928. He received the B.S. in Physics from Case Institute of Technology, Cleveland, in 1947, and the Ph.D. in Physics from the University of Chicago in 1949.

He is IBM Fellow Emeritus at the Thomas J. Watson Research Center, Yorktown Heights, New York. After three years on the faculty of the University of Chicago, he joined IBM Corporation in 1952, and was until June 1993 IBM Fellow at the Thomas J. Watson Research Center, Yorktown Heights, New York. In addition, he is a consultant to the U.S. government on matters of military technology, arms control, etc. He has been Director of the IBM Watson Laboratory, Director of Applied Research at the IBM Thomas J. Watson Research Center, a member of the IBM Corporate Technical Committee, Adjunct Research Fellow in the Kennedy School of Government, Harvard University; and Adjunct Professor of Physics at Columbia University. He has also been Professor of Public Policy in the Kennedy School of Government, Harvard University. From 1997 to 2004 he was Philip D. Reed Senior Fellow for Science and Technology at the Council on Foreign Relations, New York.

He has made contributions in the design of nuclear weapons, in instruments and electronics for research in nuclear and low-temperature physics, in the establishment of the nonconservation of parity and the demonstration of some of its striking consequences, in computer elements and systems, including superconducting devices, in communication systems, in the behavior of solid helium, in the detection of gravitational radiation, and in military technology. He has published more than 500 papers and been granted 47 U.S. patents. He has testified to many Congressional committees on matters involving national security, transportation, energy policy and technology, and the like. He is coauthor of many books, among them *Nuclear Weapons and World Politics* (1977), *Nuclear Power Issues and Choices* (1977), *Energy: The Next Twenty Years* (1979), *Science Advice to the President* (1980), *Managing the Plutonium Surplus: Applications and Technical Options* (1994), *Feux Follets et Champignons Nucleaires* (1997) (in French with Georges Charpak), *Megawatts and Megatons: A Turning Point in the Nuclear Age?* (2001) (with Georges Charpak), and *"De Tchernobyl en tchernobyls,"* (with Georges Charpak and Venance Journe) (2005).

He was a member of the President's Science Advisory Committee 1962-65 and 1969-72, and of the Defense Science Board 1966-69. He is a Fellow of the American Physical Society, of the IEEE, and of the American Academy of Arts and Sciences; and a member of the National Academy of Sciences, the Institute of Medicine, the National Academy of Engineering, the Council on Foreign Relations, and the American Philosophical Society. He served on the Council of the National Academy of Sciences 1983-1986 and 2002-2005.

The citation accompanying his 1978 election to the U.S. National Academy of Engineering reads "Contributions applying the latest scientific discoveries to innovative practical engineering applications contributing to national security and economic growth." He received the 1983 Wright Prize for interdisciplinary scientific achievement, the 1988 AAAS Scientific Freedom and Responsibility Award, the 1991 Erice "Science for Peace" Prize, from the U.S. Government the 1996 R.V. Jones Foreign Intelligence Award and the 1996 Enrico Fermi Award, the Federation of American Scientists: Public Service Award 1971 and 1997, University of Chicago Enrico Fermi Institute and Departments of Physics and Astronomy: Public Service Medal (2002), Case Alumni Association: Gold Medal (2002), Academie des Sciences (France): La Grande Medaille de l'Academie des Sciences-2002, and Fellow of the IEEE (November 2003) "for contributions to the application of engineering to national defense." In 2003 he received from the President the National Medal of Science.

From 1977 to 1985 he was on the Council of the Institute for Strategic Studies (London), and during 1978 he chaired the Panel on Public Affairs of the American Physical Society. He is a long-time member of Pugwash and has served on the Pugwash Council.

His work for the government has included studies on antisubmarine warfare, new technologies in health care, sensor systems, military and civil aircraft, and satellite and strategic systems, from the point of view of improving such systems as well as assessing existing capabilities. For example, he contributed to the first U.S. photographic reconnaissance satellite program, CORONA, that returned 3 million feet of film from more than 100 successful flights 1960-1972. He contributed also to the current electro-optical imaging systems and various electronic intelligence satellite systems deployed by the U.S. government.

He has been a member of the Scientific Advisory Group to the Joint Strategic Target Planning Staff and was in 1998 a Commissioner on the 9-person "Rumsfeld" Commission to Assess the Ballistic Missile Threat to the United States. From 1993 to August 2001, he chaired the Arms Control and Nonproliferation Advisory Board of the Department of State. On the 40th anniversary of the founding of the National Reconnaissance Office (NRO) he was recognized as one of the ten Founders of National Reconnaissance.

Since 2009 he has been a consultant to the Office of Science and Technology Policy in the Executive Offices of the President. In 2010 he was a consultant to Secretary of Energy Steve Chu on the Deep Water Horizon (BP) oil spill, and in 2011 he supported Secretary Chu again on the U.S. response to the damaged reactors at Fukushima Dai-ichi.

(Biography current as of 08/13/12)

*Comments on Peer Review and Design Competition in the NNSA National Security Laboratories**

Roy Schwitters

January 11, 2016

On 1/5/2016, I received an email from the Counsel to the Strategic Forces Subcommittee of the House Armed Services Committee, inviting me to testify the following Tuesday, 1/12/2016 to the Subcommittee to provide context and alternative perspective on a recommendation to build new prototypes of nuclear weapons made in the recent NAS report on peer review and design competition in the NNSA national security laboratories (for reference, see footnote below; in this note, I refer to this document as "the NAS report"). Due to other commitments, I declined the invitation to testify. This note outlines my views on the subject NAS report.

Briefly, the NAS report deals with two crucial issues in stockpile stewardship: 1) providing quality assurance in the maintenance of the nuclear deterrent through inter-laboratory peer review, and 2) developing and retaining technical staff, both under the Nation's moratorium on explosive nuclear testing. In my view, the conclusions and recommendations regarding peer review are generally supportive of policies implemented by NNSA and its national laboratories during 2008-2010, with useful suggestions for extension and improvement. On the other hand, its second major recommendation, to develop new prototype nuclear weapons not to be entered into the stockpile, is so vague and poorly supported that it cannot be analyzed in a serious way. The intent of the recommendation, to provide important, challenging technical problems that will attract and retain qualified scientists and engineers to careers in the stockpile stewardship program, must be part of any long-term strategy to maintain the nation's nuclear deterrence, but the proposal outlined in the NAS report provides no basis for anticipating its value to U.S. deterrence, its chances of success, or its potential for launching unintended deleterious consequences. Finally, the report is spotty in terms of level of detail and is lacking in clarity, which must make it difficult, at best, for anyone not already immersed in details of the U.S. nuclear weapons program to understand what is being proposed.

I what follows, I give a personal synopsis of the report, followed by additional comments.

* Report of the Committee on Peer Review and Design Competition Related to Nuclear Weapons, The National Academies Press (2015).

The NAS Report, a Brief Synopsis

The NAS report was the product of a committee organized through the National Academies and chaired by Paul Percy and Jill Dahlburg. The study commenced in June 2014 and completed with the recent release of the report by NAS in late 2015. The Administrator of the National Nuclear Security Administration commissioned the study in response to Congressional language. The charge followed by the committee was:

“Assess the following:

- The quality and effectiveness of peer review of designs, development plans, engineering and scientific activities, and priorities related to both nuclear and non-nuclear aspects of nuclear weapons;
- Incentives for effective peer review;
- The potential effectiveness, efficiency, and cost of alternative methods of conducting peer review and design competition related to both nuclear and non-nuclear aspects of nuclear weapons, as compared to current methods;
- Known instances where current peer review practices and design competition succeeded or failed in finding problems or potential problems; and
- How peer review practices related to both nuclear and non-nuclear aspects of nuclear weapons should be adjusted as the three NNSA laboratories transition to a broader national security mission.”

The report lists four basic sets of conclusions with accompanying recommendations. The first set addresses the first two bulleted elements of the charge, concluding that the peer review process is used effectively by all three NNSA laboratories (Los Alamos, Livermore, and Sandia), that incentives for peer review at the laboratories “are abundantly evident”, that somewhat different approaches are used by the labs, and that there are opportunities for improvement.

Conclusion/Recommendation Set 2 focuses on aspects of design competition raised by the third bulleted point in the study charge, but falls short of addressing all the questions. The NAS report does not address effectiveness, efficiency, and cost of alternative approaches of either peer review or design competition. The Set 2 recommendation argues for maintaining “independent design capabilities” at Los Alamos and Livermore “to enable independent peer review of critical technical issues”, a position I strongly endorse.

Conclusion/Recommendation Set 3 assesses various deficiencies of the RRW design competition process and suggests remedies in peer review processes, which

seem to have been largely addressed by the INWAP. This would appear to represent the committee's response to a "failed" design competition/peer review practice.

Conclusion 4 states: "In contrast to the robust state of peer review at the NNSA laboratories, the state of design competition is not robust." Recommendation 4 goes on to assert that a series of design competitions that "exercise the full set of design skills necessary for an effective nuclear deterrent" and *not* contribute designs that would enter the stockpile would attract a workforce to maintain the future viability of the nation's nuclear deterrent.

The last element of the charge—how peer review ... should be adjusted as the three NNSA laboratories transition to a broader national security mission—doesn't appear, at least to me, to be addressed in the four conclusion-recommendation sections.

A Personal Assessment of Certain Aspects of the NAS Report

The crux of the report is contained in Conclusion/Recommendation Set 4. Whether the single word "robust" is sufficient to describe adequately the key issues necessary to maintain the nation's future nuclear deterrent, Conclusion 4 seems to aptly summarize this report: peer review is in pretty good shape and, with some tweaks of the INWAP process (chiefly having Sandia follow peer review procedures that engage Los Alamos and Livermore personnel or a broader range of topics than annual assessment), can work well as long as competent, motivated, and imaginative technical people are committed to the program.

Recommendation 4 focuses only on design competitions. There is no explanation of how such competitions would be formulated or how a winner would be selected. I simply do not understand how such a vague plan to engage design experts can possibly achieve the important objective, to which I subscribe, of maintaining the technical expertise and vitality of NNSA's laboratories—and its unique production capabilities.

Why is the challenge space limited to design? There are many key technical capabilities essential to maintaining the nuclear deterrent. It is a truism that capabilities must be exercised to be maintained—"use it or lose it!" What other capabilities might need regular exercise, not available during normal LEP cycles, for example?

What does one do with the successful/unsuccessful results generated from a competition? Do they cause cost concerns or proliferation concerns that will actually harm stockpile stewardship? After a few cycles in such a campaign of competitions, will the process still satisfy the fundamental need to attract and retain key people?

The report is unclear and can be misinterpreted in important sections. For example, how is a non-expert to understand the statement under Conclusion 1.3 (page 2): "With only archival nuclear explosion test data available, ..."? Unmentioned are all the other data that have been and are being actively acquired and analyzed. What is a "NEP laboratory"? Is it true that "peer review ... is recognized as a means of ensuring high-quality work products? Does "QMU systematically apply the output of the Stockpile Stewardship Program ... to assessment of the stockpile? There are other examples of non-sequiturs inadvertently created in the report, which could lead to misunderstanding of important messages. More careful editing would have been well worth the additional time and effort.

Summary

During the Cold War, the United States designed, built, tested, and deployed numerous nuclear warheads of various designs. The results of nuclear tests of the nuclear explosive packages (NEPs) of these warheads provided the ultimate validation of the design procedures, weapon design codes, and designer judgment. Formal design competitions between teams from Los Alamos National Laboratory (LANL) and Lawrence Livermore National Laboratory (LLNL)—each supported by separate branches of Sandia National Laboratories (SNL) for the non-nuclear components and integration with the delivery system—were routinely held. Extensive peer reviews of the types in use today were less frequent and less formal during that era, primarily because of the availability of nuclear explosion testing.

Following the moratorium on nuclear explosion testing that began in 1992, all three National Nuclear Security Administration (NNSA) laboratories intensified their use of technical questioning, collaborative and competitive reviews, tests of components and subsystems, and modeling and simulation to regularly check their work and ensure that a range of perspectives is brought to bear so as to improve quality and uncover any problems. The laboratories have also strengthened their technical evaluation and peer review processes both to ensure the safety, security, and effectiveness of the nuclear stockpile and to help maintain associated science and engineering design and innovation capabilities in the laboratories. Although not a substitute for weapons tests, peer review has become an increasingly important practice at the three NNSA laboratories as a

means of mitigating the risks that the nation's nuclear weapons will fail to perform as expected if needed.

After an assessment of peer review and design competition, the committee reached four conclusions:

Conclusion 1.1: In the main, peer review processes used by all three NNSA laboratories are healthy and robust, providing benefits such as increasing confidence in weapon assessment and certification, improving our understanding of weapons physics, addressing weapon aging issues, and identifying lower-cost approaches to Life-Extension Programs.

Conclusion 1.2: Incentives for peer review at the NNSA laboratories are abundantly evident.

- Peer review reduces the risk of overlooking a technical option, of relying on suboptimal data or methods, or of simply making an embarrassing mistake, and thereby supports the ingrained culture at all three laboratories, which sets a high standard for quality.
- Peer review is visibly valued by laboratory management.

Conclusion 1.3: SNL and the NEP design laboratories (LANL and LLNL) have taken somewhat different approaches to peer review, owing in large part to SNL's ability to test non-nuclear components and systems.

- With only archival nuclear explosion test data available, LANL and LLNL rely on vigorous, deep-dive reviews by true competitive peers and other subject-matter experts to critique the results of calculations and subcritical experiments relating to NEP performance.
- With testing data available to verify the performance of components and systems and to validate modeling and simulation tools, peer review at SNL is driven more by the need to assure cost-effective performance of stockpile hardware under all anticipated conditions and by budget pressures to reduce the number of expensive tests.

Conclusion 1.4: All three NNSA laboratories have opportunities to improve their processes for peer review:

- With the exception of major reviews associated with the Annual Assessment Report or Life-Extension Programs, LLNL and LANL lack written guidance for conducting peer reviews to determine in general when a review is needed, how the review is to be conducted, who should participate in the review, or how to address review findings.
- SNL has developed useful written guidance for conducting peer reviews; however, during its visit to SNL and its probing of the presentations made, the committee determined that SNL could profitably make greater use of outside experts in its peer reviews, as called for in its written guidance.

These conclusions led the committee to the following recommendation:

Recommendation 1: The nuclear weapons laboratories should improve their peer review processes in the following ways:

- Los Alamos National Laboratory and Lawrence Livermore National Laboratory should ensure they have short, written guidance for a graded approach to peer review, the rigor of which is appropriate to the stage of work and range of technical activities being reviewed.
- Sandia National Laboratories should strengthen and broaden its use of outside experts on its peer review teams, as articulated in written guidance that Sandia recently finalized.

In the area of design competition, the committee reached one conclusion and one recommendation:

Conclusion 2: The innovations produced by design competitions during the Cold War, as well as the increased confidence in the safety and reliability of stockpile weapons resulting from current assessment processes such as the Independent Nuclear Weapons Assessment Process (INWAP), illustrate the value of having independent teams, using different approaches and methods, addressing common problems.

Recommendation 2: Los Alamos National Laboratory and Lawrence Livermore National Laboratory should continue to maintain independent design capabilities, using different approaches and methods, to enable independent peer review of critical technical issues. Sandia National Laboratories should likewise carry out, for high-priority issues, competitive designs with independent teams that

use different approaches, followed by peer reviews of components, subsystems, and full systems, as discussed in Recommendation 1.

The Reliable Replacement Warhead (RRW) design study produced innovative designs by competing teams at LANL/SNL-New Mexico and LLNL/SNL-California.¹ However, the manner in which the study was conducted led to deep resentments at the laboratories.

Conclusion 3: Although the RRW design study succeeded in producing innovative weapon designs by the competing teams, its value was reduced because technical experts from the competing laboratories were not given the opportunity to critique one another's ideas through interlaboratory peer review or to address criticisms at the science and engineering level before the final designs were formally presented to NNSA and potential end users.

Recommendation 3: To guide future design studies and design competitions, the National Nuclear Security Administration (NNSA) should provide a formal written statement articulating the design requirements and objectives, along with the selection criteria, in advance of any authorized work. NNSA should also ensure that interlaboratory peer review takes place and that competitors have an opportunity to address criticisms at the science and engineering level before the results are formally presented to stakeholders outside NNSA.

Finally, the committee is deeply concerned about the state of design competition at all three laboratories. There have been no full² design competitions for NEPs since the 1992 moratorium on the testing of nuclear explosions. The Department of Defense (DOD) has not asked for any fundamentally new warhead designs, and for a considerable time Congress limited work on new designs.

¹ The Reliable Replacement Warhead design study was intended to generate competitive designs for a highly reliable warhead with enhanced surety. In addition, the competition aimed for a design that could be manufactured relatively easily with currently available materials, eliminating some potentially hazardous materials that had been used previously. Finally, it was necessary that the weapon as designed could be certified without nuclear explosion testing.

² By "full design competition" the committee means competitions that integrate the full end-to-end design process, including design of the integrated NEP—from conceiving of a novel design to address a threat, through production of an engineering prototype, a step that provides essential feedback about the practicality of a design. Full design competition would not include nuclear explosion testing.

Design competitions, and the subsequent testing of components, subsystems, and systems (within the limits of national policy and agreements) are critical to developing the next generation of nuclear weapons designers with expertise that goes beyond analysis and modeling. Although it was considered too expensive for every design competition to result in the production of a prototype during the Cold War, those that did provided the feedback that designers needed to stay at the cutting edge. The number of the NEP laboratories' science and engineering personnel with hands-on experience in nuclear weapons design and nuclear explosion testing continues to decrease and will reach zero in the next decade or so. Once this experience is lost, it could limit the nation's strategic options, and it will be difficult to reestablish.

Looking to the future, maintaining nuclear weapons design skills at the NEP laboratories—as well as production skills within the NNSA complex—is essential to achieve three objectives:

1. Maintaining a credible nuclear deterrent workforce that is capable of designing and building weapons to meet evolving threats;
2. Understanding the status and direction of foreign nuclear weapon programs, and thus strengthening the nonproliferation regime; and,
3. Determining the best and most cost-effective approaches to resolving problems that arise during stockpile weapon surveillance and life extension programs.

To avoid the potential of losing a capability that could be essential for responding to evolving threats, the NNSA complex needs a means of exercising, on a regular and ongoing basis, the full suite of nuclear weapons design, development, and engineering capabilities through true design competitions. Thus, the committee makes the following conclusion and recommendation.

Conclusion 4: In contrast to the robust state of peer review at the NNSA laboratories, the state of design competition is not robust.

- There have been no full NEP design competitions since the 1992 nuclear explosion testing moratorium. Recent design studies have been good analysis and modeling exercises, but they did not result in actual engineering and fabrication of components and systems; thus, they did not exercise the complete set of skills required in the NNSA complex to design nuclear weapons that would be an effective deterrent, nor was the credibility of any design assessed by fabricating a device or by non-nuclear testing.

- At SNL, the need to continually replace aging or obsolete non-nuclear components in stockpile weapons, as well as the large Life-Extension Programs for the W76 and B61, have indeed exercised designers' skills. However, these exercises do not stimulate the full creativity and innovation that result from a true blank slate design competition that includes engineering and building a prototype.

Recommendation 4: In order to exercise the full set of design skills necessary for an effective nuclear deterrent, the National Nuclear Security Administration should develop and propose the first in what the committee envisions as a series of design competitions that include designing, engineering, building, and non-nuclear testing of a prototype. The non-nuclear components produced by Sandia should be integrated into the design and fabrication of the prototype. This should be done with the clear understanding that this prototype would not enter the stockpile.

Implementation of the committee's four recommendations would help develop and maintain the most important asset—a competent workforce with demonstrated skills and judgment—and instill confidence by all stakeholders (including adversaries) in the ability of this workforce to maintain the nuclear deterrent.

QUESTIONS SUBMITTED BY MEMBERS POST HEARING

JANUARY 12, 2016

QUESTIONS SUBMITTED BY MR. ROGERS

Mr. ROGERS. Your group's report says that some "recent design studies have been good analysis and modeling exercises, but they did not result in the actual engineering and fabrication of components and systems." Why is this distinction important—why should the labs be pursuing actual engineering and prototype fabrication (with the clear guidance that the weapon would not actually be produced and deployed)?

Dr. PEERCY and Dr. DAHLBURG. Analysis and modeling alone, no matter how carefully and expertly performed, can only be an approximation to reality, and the validity is limited by our assumptions and by gaps in our knowledge of physics at the extreme scales of nuclear weapons science. The Advanced Simulation and Computing (ASC) Program has improved understanding of weapons physics and has enabled the performance of unique basic science experiments. The data generated are useful in peer reviews and for providing feedback to nuclear explosive package (NEP) designers. However, ASC alone does not exercise the complete set of skills needed for actual design and engineering of an NEP. I fully concur with our committee's assessment of the future, wherein maintaining the full range of nuclear weapon design skills at the NEP laboratories—as well as production skills within the NNSA complex—is essential, to achieve three objectives: 1) Maintaining a credible nuclear deterrent workforce that is capable of designing and building weapons to meet evolving threats; 2) Understanding the status and direction of foreign nuclear weapon programs and thus strengthening the nonproliferation regime; and, 3) Determining the best and most cost-effective approaches to resolving problems that arise during stockpile weapons surveillance and Life-Extension Programs (LEPs).

REF: Report pages 25, 48, 49.

Mr. ROGERS. In carrying out the Stockpile Responsiveness Program created by section 3112 of the FY2016 NDAA, should the program specifically look at new designs and creative solutions, or should it adhere solely to existing weapon designs and techniques? Is this the program to pursue the "clean slate" designs your report recommends?

Dr. PEERCY and Dr. DAHLBURG. While our study did not examine the Stockpile Responsiveness Program per se, the recommendations in our report suggest that such a program should explore the full spectrum of technical creativity and innovation that would be consistent with a true blank slate design competition that includes engineering and building a prototype; the report specifies that prototype design and production should exercise the full range of skills in the NNSA complex needed to produce a new weapon. However, it is important at the same time to keep in mind that the series of design competitions that the report recommends—which include designing, engineering, building, and non-nuclear testing of a prototype, with the non-nuclear components integrated into the design and fabrication of the prototype—are also envisioned by the committee to be of modest cost and managed so as to impact neither the cost of nor the schedule for delivering Life Extension Programs (LEPs) or the 3+2 program plan.

REF: Report pages 48, 49.

Mr. ROGERS. Regarding your study's recommendation for full and robust design competitions, can you elaborate on how they should be conducted? How often do you recommend such competitions be conducted, what would they entail, how many people would be involved, and how much would they cost? Do you envision this effort would require significant additional funding, or could it be accomplished through a repurposing of existing research and development programs? Do you think design competitions would detract from or complement other weapons programs, like life extension programs and infrastructure modernization?

Dr. PEERCY and Dr. DAHLBURG. Roughly speaking, the committee imagines a design competition as involving a few dozen laboratory staff members, with a larger number in the first year of each competition, plus some prototype development and experiments up to and including hydrodynamic tests. Such design competitions should be initiated periodically (perhaps every five years) to allow learning from mistakes and for the continuous development of judgment and skills of the nuclear weapons enterprise workforce. Regarding impact to other programs, our committee's consensus view is that the laboratory staff activities that would take place during

the alternative design competitions would be focused applications of science and engineering skills that should happen anyway under the laboratories' science campaign and engineering campaign, so that the incremental cost of the competitions would be modest, while the benefit to the nation would be immense.

REF: Report pages 48, 50.

QUESTIONS SUBMITTED BY MR. COOPER

Mr. COOPER. Could the NNSA labs do more to leverage other entities for peer review, such as the JASONs group, the Atomic Weapons Establishment in the United Kingdom, or cleared groups of university or industry experts? Would this lead to gains in effectiveness or efficiency?

Dr. PEERCY and Dr. DAHLBURG. First, our study committee observed that all three of the nuclear weapons labs currently recognize the need for and thus exercise the relevant multiple types of review, including: external peer review, involving persons actively engaged in equivalent work outside the lab who review a lab's work in an particular area; internal peer review, involving persons from the same lab actively engaged in equivalent work (but not in the work being reviewed), who review the lab's work in the given area; subject-matter reviews, involving internal and external subject matter experts, who review a lab's execution of, or capabilities in, particular areas of science and engineering; and, technical reviews of programs or projects, involving internal and external experts, such as this question addresses, who may not have as full a range of expertise as the people performing the original work but who provide technical scrutiny and checking of selected aspects of the work. Then, on the topic of the nuclear weapons-related systems and science reviews that the labs currently participate in during a typical year, the committee developed the following semi-quantitative conclusions: 1) Each lab already participates in some 800 nuclear weapons systems and/or weapons science-related peer reviews in a given year; 2) About half of those reviews are internal and the other half involve some experts from other NNSA labs and/or from outside the nuclear weapons complex; and, 3) Substantial staff time and resources are involved in organizing, preparing for, conducting, and responding to these already ongoing reviews. Hence, we concluded that in the main, these processes are already healthy and robust, and accordingly our report's recommendations for improvement are modest, i.e., that LLNL and LANL should ensure short written guidance for a graded approach to peer review, and SNL should strengthen and broaden its use of outside experts on its peer review teams.

REF: Report pages 11, 26, 42, 44.

Mr. COOPER. The report notes that "Recommendation 4 [the recommendation to build prototypes based on new designs] might be seen by some critics as promoting an aggressive posture that would put the United States in a position to manufacture new nuclear weapons quickly and thus fuel a new global nuclear arms race." Can you elaborate on these risks?

Dr. PEERCY and Dr. DAHLBURG. To avoid the fundamental risk of losing a core capability that could be essential for responding to evolving national security threats, our committee realized that the NNSA complex needs a means of exercising, on a regular and ongoing basis, the full suite of nuclear weapons design, development, and engineering capabilities through true design competitions. To clarify what we envision these competitions to encompass, in order to minimize the possibility of our report being misunderstood, we explicitly noted that a prototype developed in a design competition should be a "nuclear device," not a warhead. Implementation of our Recommendation 4 would help develop and maintain the most important of national nuclear security assets—a competent, focused workforce with demonstrated skills and judgment—and would instill confidence by all stakeholders (including adversaries) in the ability of this workforce to maintain the nuclear deterrent.

REF: Report pages 5, 6, 49.

Mr. COOPER. Your report stresses that a "clean slate" design competition is important. Would this respond to specific military requirements? Would it help sustain the current arsenal, or be geared toward developing a new arsenal? How often do you recommend such efforts be conducted, what would they entail, and how much would they cost? How would you ensure that this effort does not detract from other priorities such as life extension programs and infrastructure modernization, or from the mission of understanding foreign nuclear weapons designs? Are there any risks of using a clean slate approach to new nuclear weapons designs and building prototypes?

Dr. PEERCY and Dr. DAHLBURG. Our report did not propose linking these design competitions to specific military requirements. However, we noted that the design should be such that the consensus of the design community would be that the design could be certified in a manner consistent with the nuclear testing moratorium—that is, it should be close enough to a vetted design to permit that consensus. Once hands-on experience of the NEP labs’ science and engineering personnel in nuclear weapons design or testing would be lost, it could seriously compromise the nation’s defensive posture and would be difficult to reestablish. The committee unanimously judged that a blank slate approach to exercising the full range of skills in the NNSA complex needed to produce a new weapon should significantly help to ameliorate this immense risk. Please note that the other questions raised here are addressed in my responses to Questions #2 and #3 above.

REF: Report pages 47, 49.

Mr. COOPER. What other skills are not exercised through life extension programs? And should those be exercised as well?

Dr. PEERCY and Dr. DAHLBURG. Life Extension Programs (LEPs) for the warheads in the enduring stockpile systems are planned far in advance, and extend over the next several decades. In an LEP, components that are known to suffer from deterioration or obsolescence within the time frame considered in the LEP are replaced; other components that may degrade more slowly with time or fail abruptly after a time longer than that examined may or may not be replaced. As a result, the “aging clock” of these latter components continues to tick. In some LEPs, components may need to be changed to improve the safety and security of the warhead. Assessment of the performance of changed components is a significant challenge, especially because the skills associated with designing and developing nuclear explosive packages—and, in the process, strengthening understanding of the linkages between the design and performance—have not been thoroughly exercised in the nuclear weapons complex for more than 20 years. From the perspective of a long-term view, the nation must have in place the capability to anticipate and respond to potential new threats the country could face in the future. To attempt this with a future workforce without validated experience in weapon design and development would be very risky. Accordingly, reliably validated workforce experience should be cultivated and routinely exercised, in complement with and also in support of LEPs.

REF: Report pages 40, 41.

Mr. COOPER. The report notes that engineering and producing prototypes of new nuclear weapons designs will help address evolving threats. What are these threats and how would building new prototypes help address them?

Dr. PEERCY and Dr. DAHLBURG. Perhaps even in the later years of the Cold War, the nuclear threat landscape appeared more static, and the United States stabilized and reduced its stockpile. After the cessation of nuclear explosion testing, the United States and its allies put their main efforts into maintaining the existing stockpile. Today, as foreign stockpiles and their doctrines for use are modernizing, several countries are contemplating the development of nuclear capabilities, and terrorism is spreading around the world, the nuclear threat landscape consequently is again evolving. NNSA, entrusted with the responsibility of ensuring unimpeachable confidence in the nation’s nuclear warheads through its nuclear complex—which consists of the three nuclear weapons labs, the test site, and the production plants—requires for proper preparedness a focused science and engineering enterprise of high quality and technical staff of high competence and good judgment. The functions of peer review and design competition contribute essentially to these attributes, and accordingly both functions should be exercised routinely.

REF: Report pages 40, 41.

Mr. COOPER. Are there other means, such as advanced computer simulation, that could help understand new designs?

Dr. PEERCY and Dr. DAHLBURG. Advanced computer simulations would be essential to every step of the design competitions we recommend. However, as noted in response to Question #1, analysis and modeling alone, no matter how carefully and expertly performed, can only be an approximation to reality, and the validity is limited by our assumptions and by gaps in our knowledge of physics at the extreme scales of nuclear weapons science.

Mr. COOPER. Are there any risks to the quality of peer review done between Los Alamos National Laboratory and Lawrence Livermore National Laboratory if the members of the boards of both labs are identical? Might a same board provide and require the same incentives or promote the same culture, that could limit the maximum effectiveness of peer review, that might not otherwise be true of other independent peer reviews? What measures are in place to mitigate such risks?

Dr. PEERCY and Dr. DAHLBURG. The report alludes to this concern in the first full paragraph on p. 28, which reads as follows:

“With many staff and managers moving from one laboratory to another today, and with continued encouragement from DOE/NNSA and others for the two NEP laboratories to cooperate—including sharing codes and analysis practices—some observers have raised the concern that the laboratories’ independence may be compromised by moving toward more commonality. The laboratory directors should monitor the composition of peer review panels to avoid this possibility.”

Our committee believes that as long as each lab director is independently attentive and vigilant about this issue, such a possibility will be avoided.

Mr. COOPER. Did any members of the NAS committee that wrote this report have ongoing contracts with either of the NNSA nuclear design laboratories?

Dr. PEERCY and Dr. DAHLBURG. I understand that that this sort of question is one that is faced by nearly all Academies studies. How does one attract the most knowledgeable experts on a particular subject to serve on the study committee and yet ensure that the committee’s deliberations are not influenced by particular matters that give rise to conflicts of interest? The Academies have developed an elaborate vetting process used in forming committees, to balance any biases and ensure that study members will not benefit financially from potential committee activities or recommendations. The National Academies vetting process was fully exercised for our study. Moreover, the report of our 14-member committee is a consensus product; all members agreed with the entire document, which was also reviewed by an independent set of nine outside experts (listed in the report). Because it successfully went through that external review, the report is an official product of the National Academies of Sciences, Engineering, and Medicine, and not of the study committee members.

QUESTIONS SUBMITTED BY MR. FRANKS

Mr. FRANKS. How urgent is the issue of expert nuclear scientists and engineers, who know how to design and build these nuclear devices, retiring and leaving the industry? Will these competitive design programs mitigate these critical losses?

Dr. PEERCY and Dr. DAHLBURG. The number of nuclear explosion package (NEP) laboratories’ science and engineering personnel with hands-on experience in nuclear weapons design and nuclear explosion testing continues to decrease and—unless changes are made—this number will reach zero in the next decade or so. Once NEP hands-on experience would be lost, it could limit the nation’s strategic options, and it would be difficult to reestablish. Accordingly, the issue is very urgent. Although it was considered too expensive for every design competition to result in the production of a prototype during the Cold War, those competitions that did reach the prototyping stage provided the feedback that designers needed to stay at the cutting edge. Hence, today as well, design competitions, and the subsequent testing of components, subsystems, and systems (within the limits of national policy and agreements) are critical to developing the next generation NEP designers with expertise that goes beyond analysis and modeling. It is the committee’s strong consensus view that design competitions as described in our report would exercise the full set of NEP design skills necessary for an effective nuclear deterrent.

REF: Report pages 5, 47, 48.

